XIX.—The Casting of Heavy Pottery.

By B. J. ALLEN.

ABOUT two years ago I read a paper before the Refractory Materials Section of the Ceramic Society and gave some idea of the methods employed to cast pottery under reduced pressure.

To-night I intend to briefly describe some further developments.

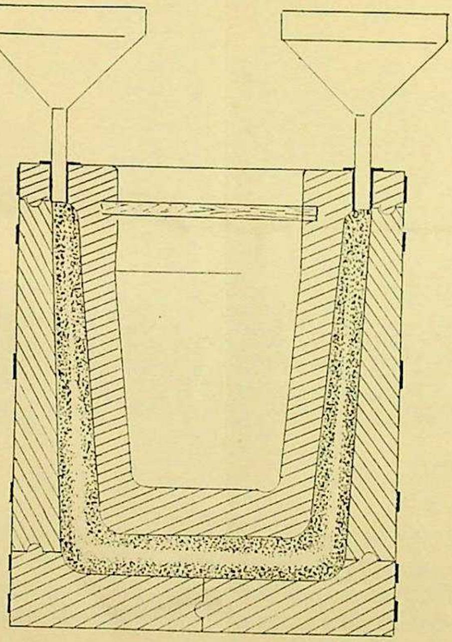

Fig. 1.

Only a few of the members present are directly interested in the articles I shall refer to, but I hope to put some ideas before you which I trust will be interesting.

I propose to deal first with the casting of heavy pottery in plaster moulds under ordinary atmospheric conditions, then

briefly to refer to the process described in my previous paper, and finally to describe the development and illustrate how the methods can be applied to the requirements of some of our local industries.

Fig. 1 shows an ordinary cored mould to produce open pots such as are used in glass works, the lining of steel ladles, or similar purposes. The slip is run into the mould through the funnels which are filled to give a good "head." If the mould and slip are in the right condition a fairly good casting may be obtained, but this method of casting has its limitations. It is very difficult to cast the centre solid, and it appears to be impossible to get anything approaching the same density of structure in the centre as

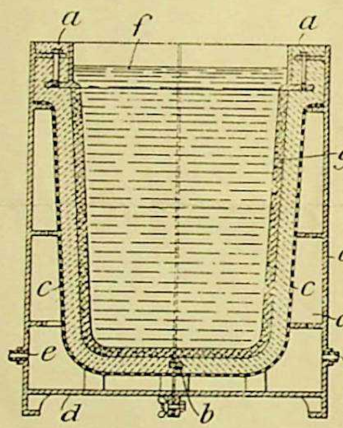

Fig. 2.

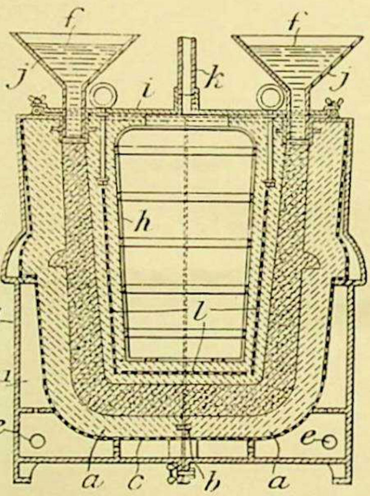

Fig. 3.

at the faces of the piece. Carelessness in filling the mould, or if the slip is not properly mixed, will result in a hollow casting. I have tried to show on the slide the sort of structure you are likely to get with this class of mould when casting articles 2 in. or more in thickness.

It is possible to get over the difficulty to some extent by first casting a core, placing it in the mould and casting round it. This will give a much better piece than casting without a liner or core, but the article will have obvious signs of lamination and be unsatisfactory for refractory purposes.

With this brief reference to some of the snags in manufacture by well-known methods, we will pass on to the casting of pots under reduced pressure.

Figs. 2 and 3 show two moulds fitted with airtight casings arranged so that the air can be removed from the space between the plaster and the casing by means of an air pump. In use, the slip is run into the mould through the funnels, or in the case of the open mould run direct into it, then the air is exhausted and the vacuum maintained until the result desired is obtained I do not think I need labour the point that as long as the clay is in contact with the plaster and the vacuum maintained the extraction of water from the slip will continue and the thickness of clay deposit increase.

If the thickness of clay is abnormal, or a quick casting required, pressure may be applied to the slip in addition to the vacuum.

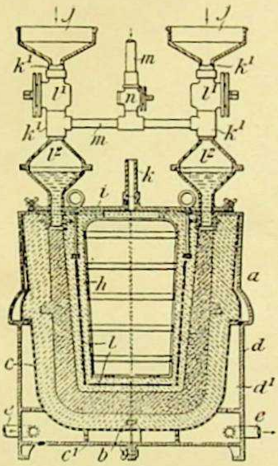

Fig. 4.

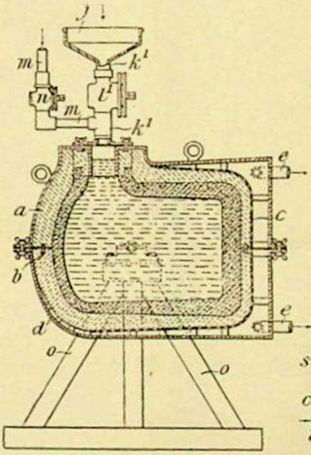

Fig. 5.

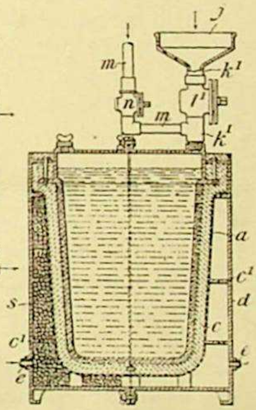

Fig. 6.

Figs. 4, 5 and 6 show the method of applying the pressure to three different moulds. Here the funnels are fitted with full bore stop-cocks and reservoirs through which the slip passes to the mould and below the stop-cocks a connection to an air compressor.

When the mould has been filled and working for a short time under vacuum the stop-cocks to the funnels are closed and compressed air admitted to the top of the slip. The advantages of applying compressed air to the one side moulds, shown by Figs. 5 and 6, is not so important as its application to the cored mould shown by Fig. 4.

I have already shown the possible defects of casting in a two-side mould; now if you require a very thick piece, with

tapering sides, the difficulty will be intensified. It will be obvious that if the bottom is twice the thickness of the top the rim will be cast dry and hard, whilst the interior of the bottom and part way up the side is still soft. The problem we have to deal with is, how to get the slip supplied to those thick parts before the thin parts are hard. The application of pressure to the slip supply will do this. You all know the action of a filter press and how soft the clay remains in the vicinity of the supply nozzle, and how the soft supply can be traced down the centre of the cake of clay. The same principle is applied to the casting of the pot. The pressure forces the clay slip through the thin part and keeps the way open until the lower part will take no more, then fills up to the inlet feed and makes a sound pot. The casting of a pot under these conditions gives you a beautiful surface of fine clay on both inside and outside of the piece.

This type of mould is very suitable for lining the inside of a refractory pot with special material. For example, zirconia may be cast on the core by dipping, and then placed in the outer mould and the fireclay or other refractory mixture cast on it.

We now come to the casting of a covered pot and it is here, I think, that the vacuum process is indispensible if a perfect piece is to be produced.

Fig. 7 shows a modification of the mould illustrated in my previous paper. It is constructed in four parts: base, two side moulds and mouthpiece. You will notice that the vacuum chamber at the sides only extends a short distance. The object of this is to permit of the base and sides near the bottom being cast thicker than the top. No provision is made on this mould for tilting to empty out the superfluous slip. The labour in tilting can be dispensed with by using a vacuum tank and sucking the superfluous slip from the mould. The saving of labour is a big consideration now, and the removal of the slip by suction is a cheaper, simpler and much cleaner method of removing what is not wanted.

So far I have only dealt with moulds where a jacket is applied to each individual mould which on account of cost could only have a limited application.

Fig. 8 illustrates a development in the construction of vacuum casings and shows how the process can be simplified, cheapened. and made adaptable to various sizes of articles The drawing shows a "Dandy" pot such as is used in some glass works. The mould is constructed with a framework of wood arranged with runners so that the mould can slide into the vacuum box like a drawer into a chest. The vacuum box shown is of wood

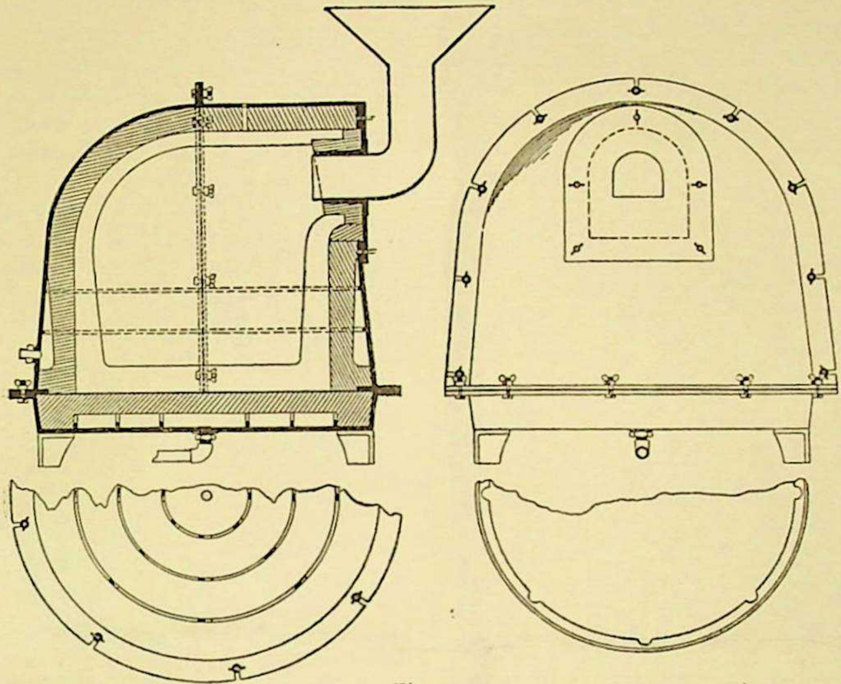

Fig. 7.

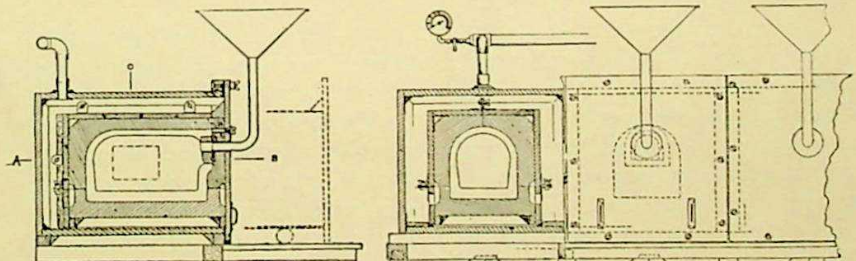

Fig. 8.

covered on the outside with zinc, and the joint at the front made with a soft rubber washer tacked to the case. This arrangement permits a number of moulds being put into one vacuum chamber. The wood runners can be constructed to adjust the size of mould to the box, serve to protect the plaster from injury, and also form an easy attachment for the wire netting with which the mould is re-inforced.

This method is not confined to the manufacture of small articles. A 38 in. dog house pot, such as is illustrated by Fig. 7, can be dealt with in a similar way, but in this case wheels would be fitted to the bottom of the mould to permit easy withdrawal, etc. I may mention that over 30 cwts. of slip is required to fill a 38 in pot mould.

Now coming nearer home. Fig. 9 shows a mould for casting enamelled fireclay lavatories under vacuum. The construction of the plaster parts only varies from the moulds used for the ordinary process of casting in the adoption of the wood framing. and the back mould which is arranged to be attached to the airtight door. With this arrangement the white engobe can be filled into the mould and cast up to any desired thickness, then the superfluous material run off and the fireclay run in and cast up solid.

The demand for fireclay with a thicker engobe will be insistant in the near future, and this method of production or an equivalent must be used. The life of the engobe, often less than $\frac{1}{16}$ in. thick, such as at present sold, is not enough, and it is up to the enamelled fireclay manufacturers to produce something better.

Fig. 10 shows a bath mould constructed on similar lines. In this case a ferro-concrete chamber with metal front and door are shown, and the mould supported on " T " iron bearers which act as runners. The plaster mould is framed in wood having suitable apertures to expose the plaster and does not vary much from a mould for pressing baths as far as the outside mould is concerned. The engobing and filling with fireclay take place in much the same way as described for the lavatory. When cast up the mould is withdrawn and the core removed, then the front and side moulds, leaving the bath resting on the base mould ready for upending and removal to the stove or glazing shop. The provision of duplicate bottom parts would permit the complete mould being immediately returned to the vacuum chamber and another bath cast. I am expecting that in the near future porcelain enamelled baths of the finest quality will be produced by this method at the rate of one finished bath per mould every twenty-four hours, and at a cost which will permit prices to compete with the better class of enamelled iron.

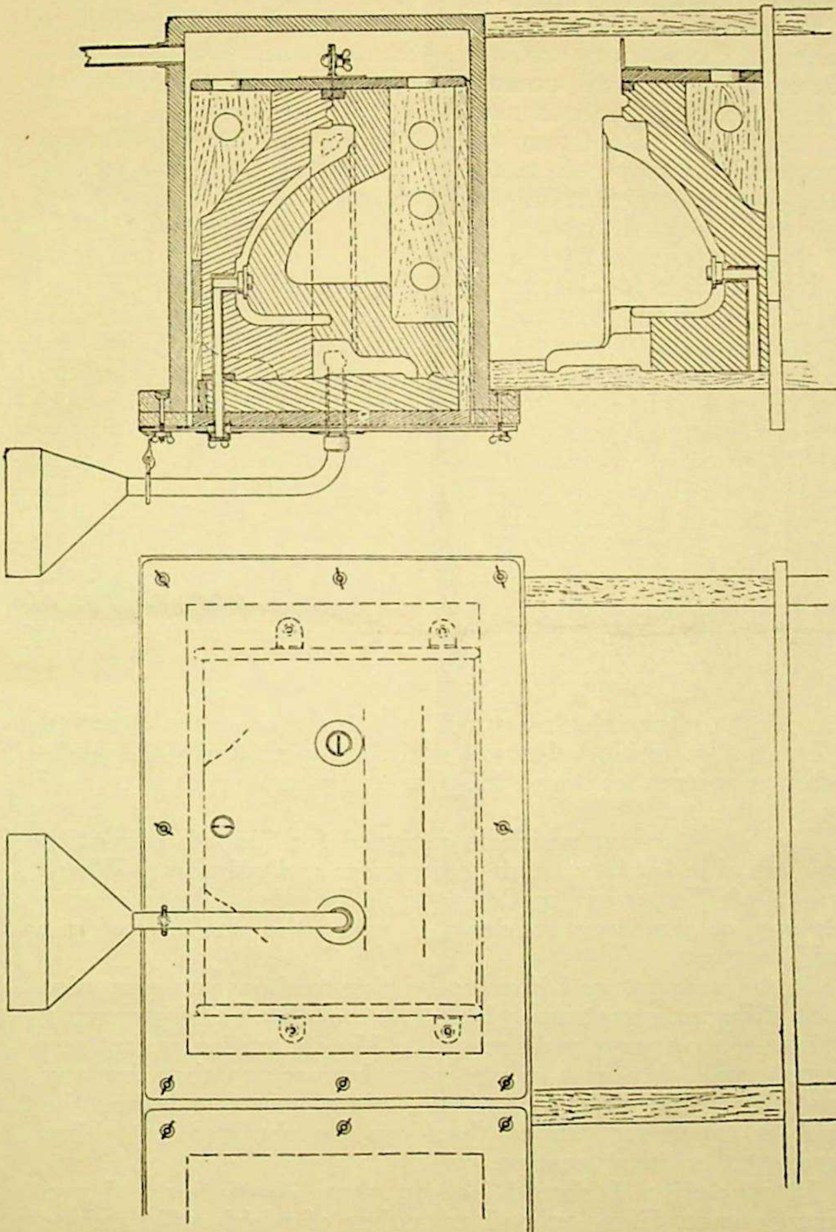

Fig. 9.

The space at the top of the ferro-concrete chamber is not wasted. Lavatory moulds such as are shown by Fig. 9 could be accommodated and leave sufficient room for the workers on the top of the platform without interfering with the bath makers. The chamber for bath moulds could also be used for gas retorts or any other big piece of similar overall dimensions.

At a later date I may show you the drawings of a factory designed to employ this method, and illustrate how the process lends itself to efficient organization and maximum production with a minimum of labour.

Fig. 11 shows the arrangement of multiple moulds for casting Sinclair insulators. In this case a two-piece plaster mould is used and the cores, with screw thread complete, are of porous pottery, also cast. The slip is fed to the bottom row of moulds, runs up the duct at the back, fills the top row and then gets a head of slip by running up the pipe to the level of funnel. If any air should be imprisoned the small ducts at the base of the cores which are connected to the vacuum space eliminate the danger as soon as the vacuum is produced. The cores need not be porous if a high vacuum is used. Specially designed metal cores with a plaster filling may be used.

For high tension electrical insulators I think there is a great future for vacuum casting. If reconstruction goes on the lines already suggested, and high voltages are carried long distances, then the demand for this class of pottery will be enormous, and I am convinced that throwing and turning will not fill the bill. High voltage electricity will find the weakness in a thrown piece in a way nothing else will, and there are often weaknesses in thrown pieces of large sizes as every maker of electrical porcelain knows.

The same casing which is designed for Sinclair insulators is also suitable for large high tension intake insulators. Where many of the latter are made it would be advisable to design the plant for the large articles and adopt the smaller multiple moulds to suit.

In the near future I hope to be able to show you examples of the different structures which can be obtained by varying the degree of vacuum and pressure. My contention is that you can get more clay in a given space by vacuum than by any other commercial process and the piece, when it leaves the mould, is very much dryer than can be obtained by either pressing or ordinary casting.

In conclusion I should like to show illustrations of two vacuum pumps, Figs. 12 and 13, either of which will produce a vacuum within 6·5 in. of atmospheric pressure.

An efficient pump is indispensable for satisfactory working, and the apparatus illustrated appeals to me as being ideal for

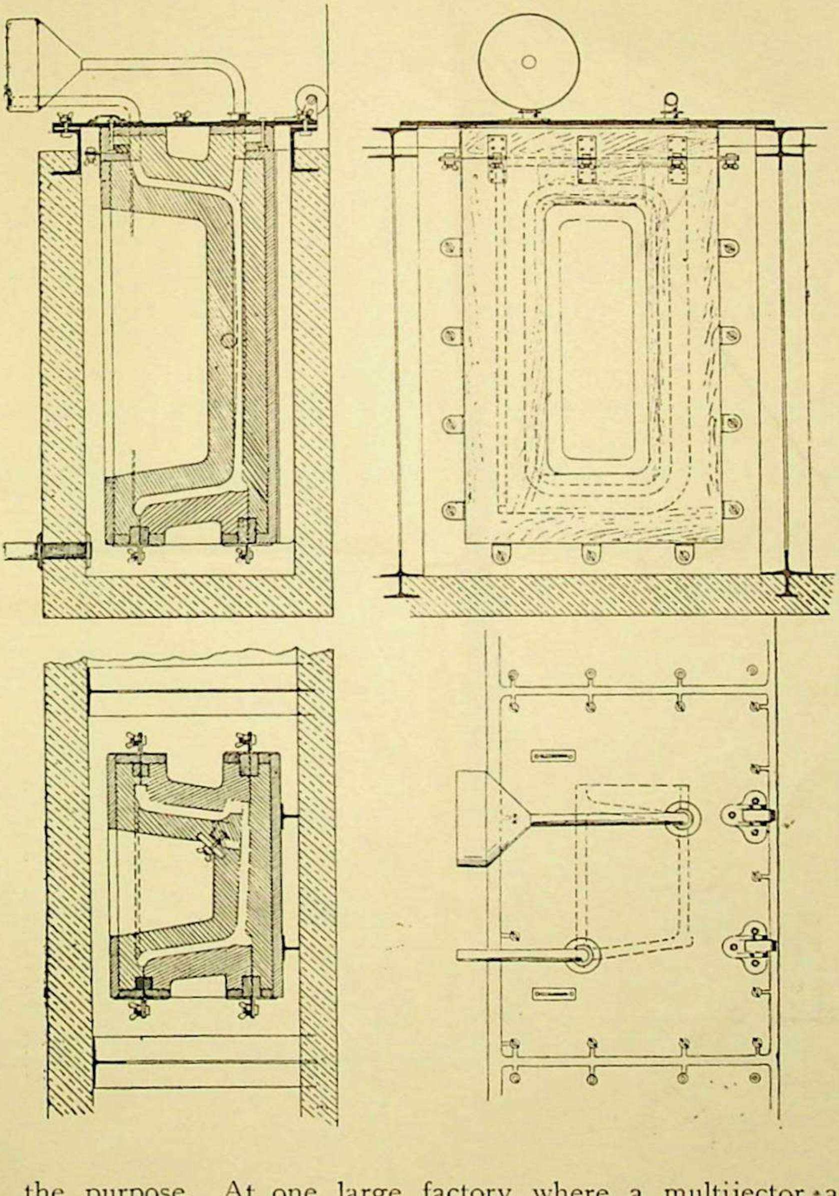

Fig. 10.

the purpose. At one large factory where a multijector air pump is employed, a vacuum of 29·5 in. was shown on the gauge

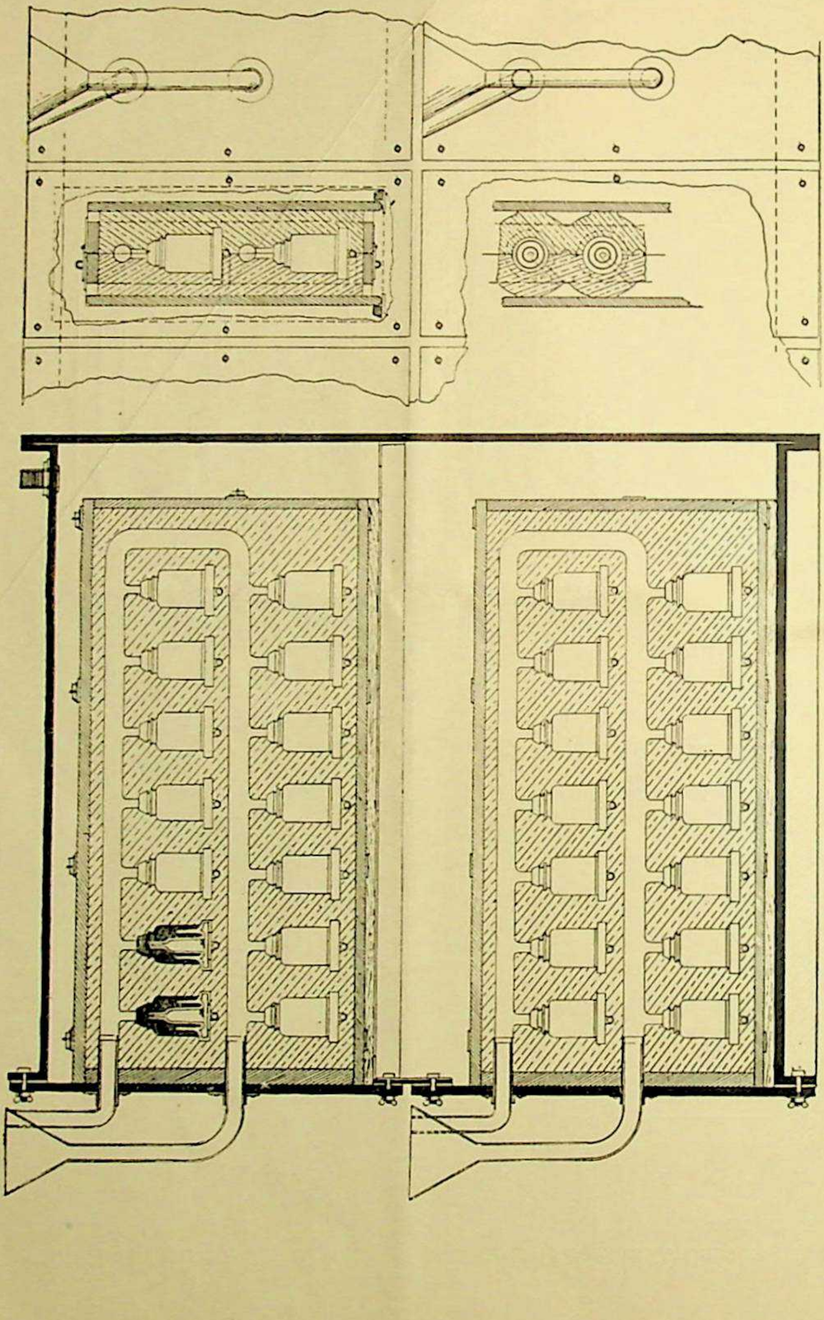

Fig. 11.

with the barometer at 30 in. The working conditions, however, were very favourable. Superheated steam at 120 lbs. pressure

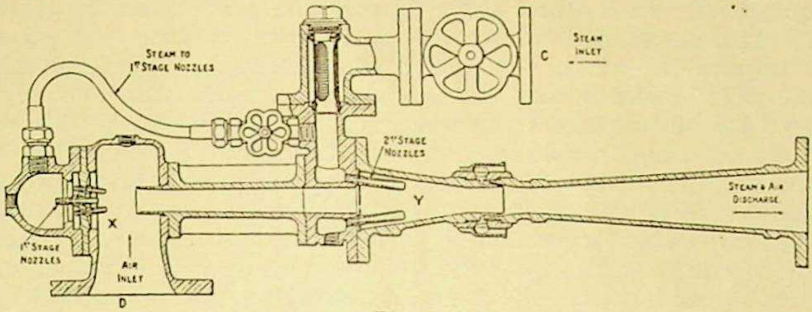

Fig. 12.

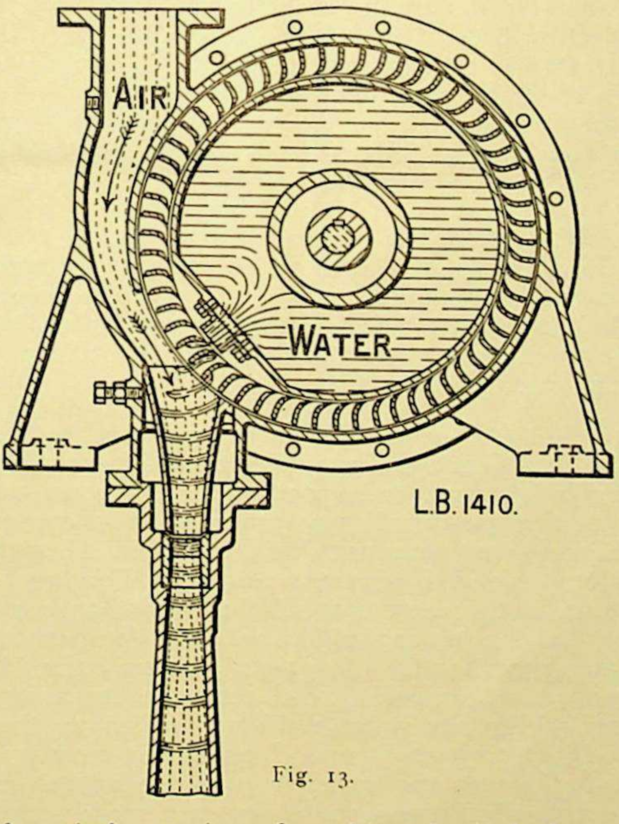

Fig. 13.

was used, and the casting of a white plastic body was $1\frac{1}{2}$ in. thick on the mould.

DISCUSSION.

Mr. A. LEESE:—I would like to ask Mr. Allen several questions. In the first place, what is the particular advantage of vacuum casting? Secondly, what is the advantage of using a core in the mould? Thirdly, whether he has tried feeding the pots at the bottom instead of at the top? And fourthly, how far he has tried this method in a practical way? A core must be a big trouble in casting pottery, and it is not always the best way, because, so far as I know, you do not get the body so even in composition and construction as you would with an open filling mould. Then Mr. Allen has made reference to thrown and turned insulators. I was wondering whether the lecturer has tried these insulators in an exposed atmosphere for any length of time, in both the winter and the summer, because there is a wide difference between cast ware and thrown and turned. I can hardly see how a vacuum is equal to pressing by hand if that is done in a proper, workmanlike way. I must say that the paper is a very elaborate one, and very well illustrated. I should be pleased if the lecturer could answer these few questions. Even if they are not properly put someone may learn something by the replies, and after all that is what this Society is for.

Mr. W. CLEVERLY:—I would like to ask whether the running in of the fireclay after pieces have been engobed with zirconium does not tend to remove the zirconium coating, and also if the vacuum is sufficient to remove any air bubbles which might be carried into such a thick piece as a glass-pot by the slip being under pressure.

Dr. MELLOR:—I would like to congratulate Mr. Allen upon what I consider a brilliant exposition of the whole principle of casting by pressure and vacuum. As is known quite well, vacuum casting (so-called) was practised in a crude sort of way at Sèvres many years ago, but I think Mr. Allen's developments a most decided advance. As Mr. Allen knows, there was trouble in the early days of the war in getting suitable glass-pots for the making of optical glass for periscopes and various appliances for the use of our soldiers before the glass was taken up at Sheffield, and I remember speaking to Mr. Allen and asking him if he could not hasten up the process somehow by casting glass-pots. I remember pressing it fairly strongly to him at the time. I was referring then to the ordinary casting of glass-pots under usual conditions. I had one doubt about the casting. A glass-pot has, of course to withstand the action of a corrosive, molten glass for a good long time.

The conditions are very much the same as those which occur in the bottom of a frit kiln making a lead frit. The corrosive action is very great, and under ordinary conditions of casting I am not sure that the cast pot would not be just a little on the porous side. I spoke to Mr. Allen about this last week. I think that with his application of vacuum pressure to the casting he will be able to get a better "density," and a better all-round result than with ordinary casting. In large articles which are to be subjected to great heat, one of the difficulties is to get the pot of homogeneous texture throughout. When the pot is built up by hand this is exceedingly difficult, and a great many of the faults in refractories are, in my opinion, due to the heterogeneous texture, so to speak, of the body. I think with Mr. Allen's process, if he can so arrange it that it is almost fool-proof, and bring it under perfectly easy control, which I have no doubt he will be able to, it will be possible to produce glass-pots which will give a much better result than some of those now in use. Mr. Allen's reference to electrical goods is also interesting. The breakdowns are due not so much to the materials as to interruptions in the continuity of the material, by flaws, blebs, and the like. These are the places which first break down under high voltages.

Mr. B. J. ALLEN:—Mr. Leese's questions are always interesting, and I will do my best to reply to them. But I would like to explain at the start that the paper is a scrappy one, only supposed to occupy twenty minutes, so that it has not been possible to fill in all the details that may be desired. It was only intended to be a brief outline of the development from simple casting to vacuum and multiple casting, and to show modifications of the methods.

With regard to the advantages of vacuum casting, I think Mr. Leese has supplied his own answer. In the first place, I only suggest this process for heavy articles of great thickness, or where you require a definite density.

The difference between an ordinary cast article and a thrown and turned one is admitted. We all know that the cast insulator, cast under ordinary pressure, is not as good as the thrown and turned one. It is to get the cast insulator superior to the thrown and turned one that I suggest the vacuum process. The advantages for certain refractories is that you can get a density under vacuum and pressure that is a physical impossibility by ordinary pressing or by casting without a vacuum. A piece cast under vacuum with the maximum pressure will give more clay in a given space than it is possible to get by pressing. All the time that you are casting the piece under

vacuum you are carrying fine clay into the fissures or pores and feeding them full. The great advantage, however, is in the homogeneous structure produced. If you break down a piece of clay with hot water the structure can easily be determined. Pugged clay breaks down in parallel lines, a thrown and turned piece in spiral lines, a pressed piece breaks down so as to show all jointing of the clay, whilst a vacuum cast piece does not appear to show disintegration along any lines whatever.

With regard to using a core. To cast a piece more than three or four inches thick you would have a difficulty in getting the required thickness on a single face of plaster within a reasonable space of time, and often the interior of the article is required with a fine face, whereas the outside does not matter so much. Under these conditions it is necessary to have a core, and where you employ a core you require to get some means of filling the centre of the casting, such as I have illustrated in my first diagram. Otherwise you get a defective piece.

Concerning the weathering of insulators, etc. The difficulties of atmospheric conditions we know. But my contention is that you can cast insulators under vacuum so that faults such as are common in ordinary cast articles or thrown and turned will be eliminated.

With regard to feeding the moulds at the bottom instead of at the top, this does not make much difference, because with a vacuum the pressure will be the same all over the piece. The clay casts up on the top of a covered pot just the same as it does at the bottom providing the plaster is sufficiently exposed. The diagrams, however, show the feed at the bottom wherever the design of the article permits.

In reply to Mr. Cleverly, the zirconium or other engobe on the plaster core is held in position by the vacuum that is maintained inside the core, and it is possible to run the supporting material round it without any great disturbance. There will be a certain amount of friction caused by the clay or other refractory running round, which will carry some of the engobe along with it, but the bulk of the material removed will be carried along automatically with the slip, and cause no trouble. Supposing it does mix with the fireclay in the immediate vicinity of the engobe, that is likely to be an advantage rather than the reverse, and if you cast it on sufficiently thick and get it sufficiently dry there will be no difficulty. The same remarks are applicable to the casting of an engobe on to a lavatory mould to be filled with fireclay. In this case there is really a big advantage in the little friction which causes an

intimate mixture between the fireclay slip and the engobe just where the junction takes place.

The application of pressure to slip does not put air into the material at all, the tendency is to take it out. Pugged clay, which has not been slipped, contains from 5 per cent. to 15 per cent. by volume of air. Slip should not contain more than 2 per cent. or 3 per cent., and the bulk of this would be removed under vacuum, so that the advantage of vacuum casting insulators, glass-pots, etc., will be obvious.